# Progress Report

January 14, 2015

Steam Enhanced Extraction at the Former Williams AFB, ST012 Site

Mesa, AZ

# 1. Summary

This report covers the period of operations from Tuesday, January 6, 2015 through Monday, January 12, 2015. The following table provides a summary of the project operational status.

**Table 1. Project Summary**

| | Value | Unit |
|---|---|---|
| Target Treatment Zone (TTZ) Soil Volume | 410,000 | cubic yards (cy) |
| Area | 199,000 | square feet ($ft^2$) |
| Upper Depth of Treatment | 145 | feet (ft) below ground surface (bgs) |
| Lower Depth of Treatment | 245 | ft bgs |
| Vapor Liquid Treatment Started | 09/29/14 | |
| Thermal Operations Started | 09/29/14 | |
| Last Process Data Update | 01/12/15 | |
| Last Temperature Data Update | 01/12/15 | |
| Estimated Total Days of Operation | 422 | days |
| Days of Operation | 105 | days |
| Days of Operation vs. Estimate | 25 | percent (%) |
| Estimated Total Energy Usage | 11,343,000 | kilowatt hours (kWh) |
| Total Energy Used | 830,980 | kWh |
| Used Electrical Energy vs. Estimate | 7 | % |
| Total Steam Injected | 53.4 | million pounds (lbs) |
| Projected Total Steam Injection | 320 | million lbs |
| Steam Injected Vs Projected | 17 | % |
| Mass Removed in Vapor Based on Photoionization Detector (PID) Readings | 93,420 | lbs |
| Mass Removed as NAPL | 46,283 | lbs |
| Total Vapor and Liquid Mass Removal (based on PID readings) | 139,704 | lbs |
| Average Power Usage Rate Last Week | 328 | kilowatts (kW) |
| Average Wellfield Vapor Extraction Rate Last Week | 230 | standard cubic feet per minute (scfm) |
| Average Condensate Production Rate Last Week | 0 | gallons per minute (gpm) |
| Average Water Extraction Rate Last Week | 79 | gpm |
| Total Water Extracted | 14,335,221 | gallons |
| Recovered Light Non-Aqueous Phase Liquid (LNAPL) | 7,034 | gallons |
| Average Water Discharge Rate Last Week | 112 | gpm |
| Total Treated Water Discharge | 17,807,000 | gallons |

Operational highlights from the past week are presented below:

- Eductor skids were cycled so that three eductor skids were running at a time. Each day, the schedule was adjusted so that each skid was offline for an approximate one-day period. The average liquid extraction rate from the formation was approximately 80 gpm over the past week.
- During the liquid extraction system restart, three multi-phase extraction (MPE) wells were identified as nonfunctioning and are scheduled to be pulled and replaced.
- On January 6, 2015, a hose separated from the pump at the camlock fitting during the pump out of the carbon backwash tank and approximately 100-150 gallons of carbon backwash water spilled to surface (freshwater used to backwash both the used and new liquid carbon). The spill was contained within the process equipment area and approximately 100 gallons of water was recovered. The soil within the impacted area was sampled.
- On January 8, 2015, the steam injection rate was increased in 9 Lower Saturated Zone (LSZ) wells and 4 Upper Water Bearing Zone (UWBZ) wells. The target injection rate was 2,200 pounds/hour (lbs/hr) in the LSZ and 1,100 lbs/hr in the UWBZ.
- The remaining 6 LSZ wells and 3 UWBZ were kept at a maintenance mode steam injection rate corresponding to approximately 300-400 lbs/hr. These wells are all approximately 100 ft from a MPE well that needs to be pulled. For health and safety reasons, the injection rates at these wells will be kept at a minimum until the nearby MPE wells are back online (anticipated to be by the end of January pending driller's schedule).
- The current total steam injection rate in the LSZ is 22,500 lbs/hr.
- The current total steam injection rate in the UWBZ is 5,100 lbs/hr.
- Eleven temperature monitoring points are showing a response to the steam injected.
- In response to perimeter groundwater levels collected on January 11, 2015, the steam injection rate in the LSZ wells was reduced to 1,100 lbs/hr in 9 LSZ wells on January 12, 2015.
- On January 13, 2015, another round of groundwater levels was collected and data indicated a substantial decrease in perimeter groundwater levels.
- Collected process, wellfield and laboratory data per the sampling schedule.
- Conducted regular maintenance on the treatment system.

## 2. Vapor Extraction

Figure 1 below shows the vapor extraction rate from the site. Note that the estimated steam extraction rate is a calculated value based on the water generated at the moisture separators after cooling the vapors from the wellfield.

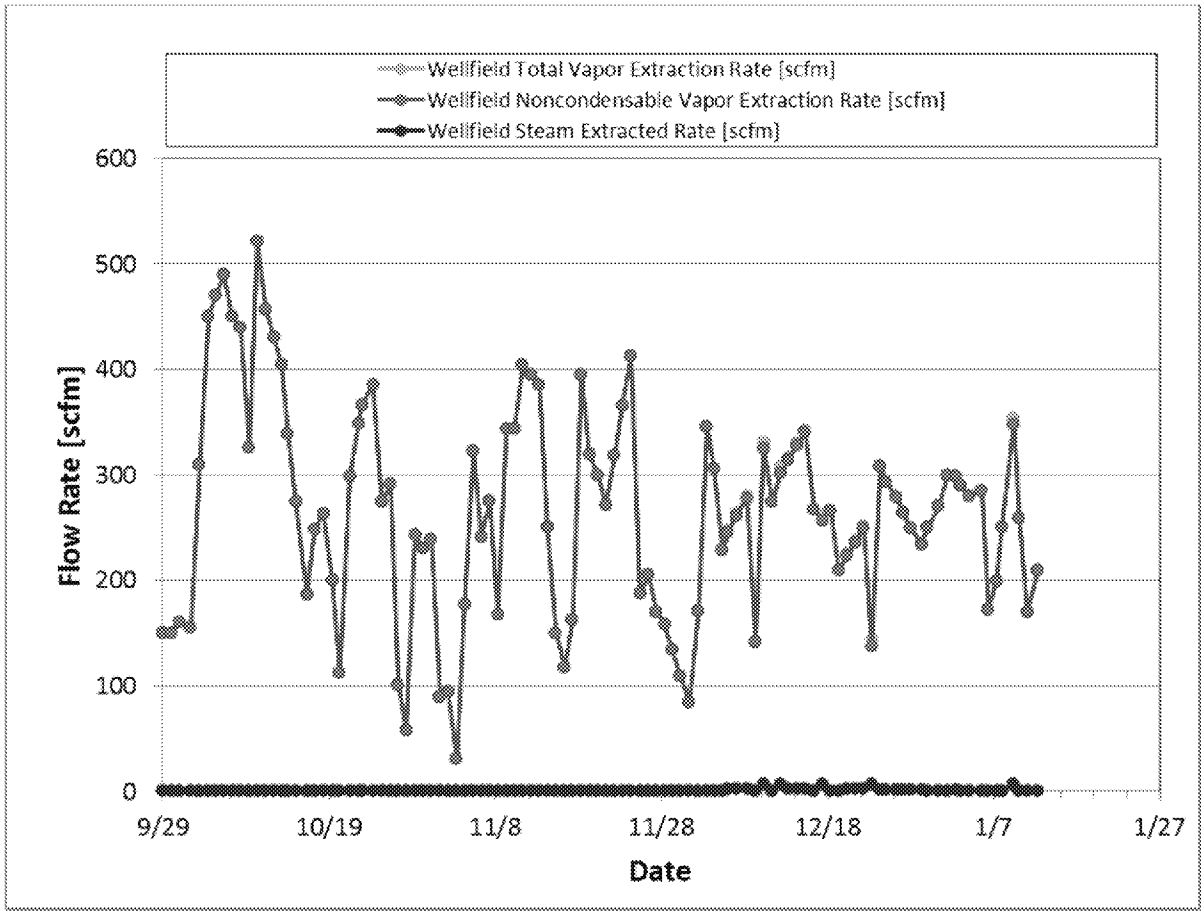


**Figure 1. Vapor Extraction Rate**

# 3. PID/FID

The following figures depict the PID/flame ionization detector (FID) concentrations from the wellfield effluent to the effluent of the thermal accelerators. Figure 2 shows PID readings collected since the start of operations. Figure 3 shows the FID readings beginning October 18, 2014. Note that PID/FID readings of 0.0 parts per million by volume (ppmV) are shown in the figures as 0.01 ppmV due to the logarithmic scale that does not allow display of 0-values.

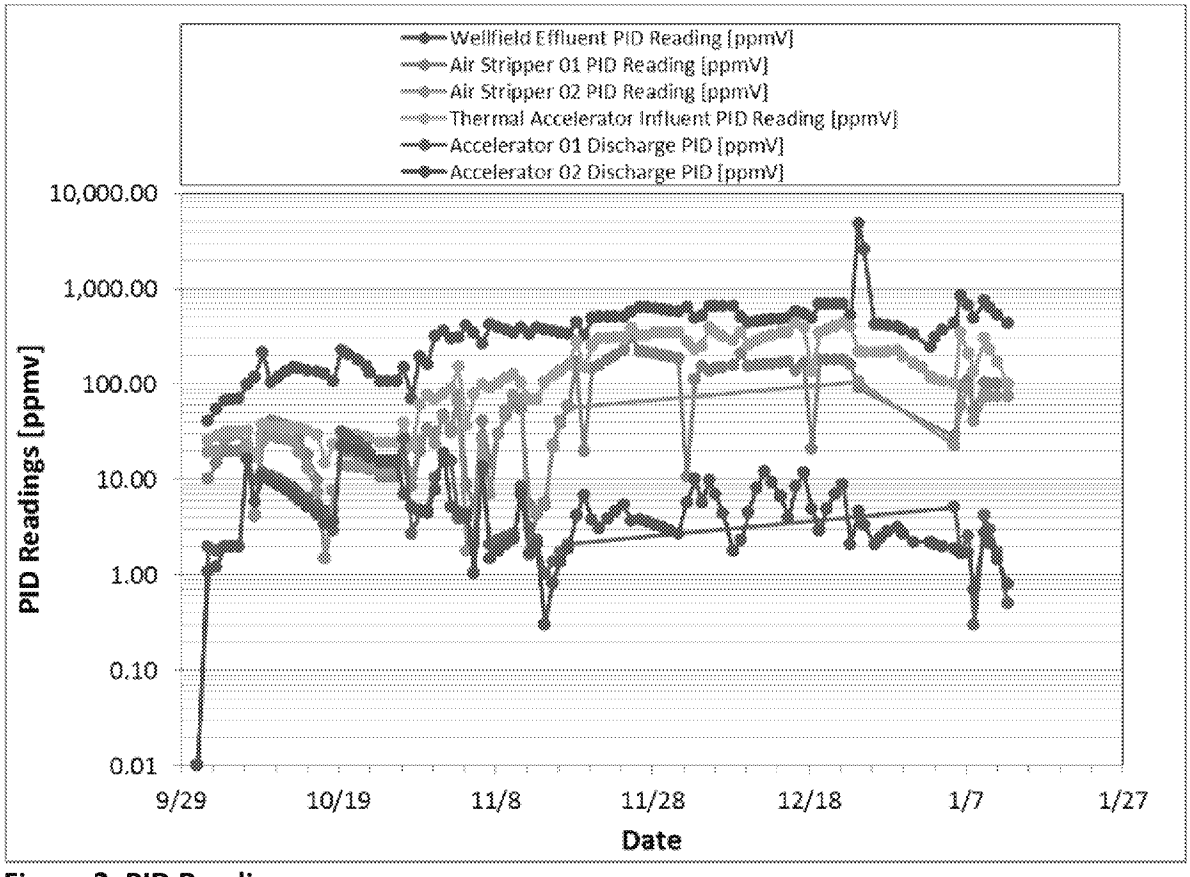


**Figure 2. PID Readings**

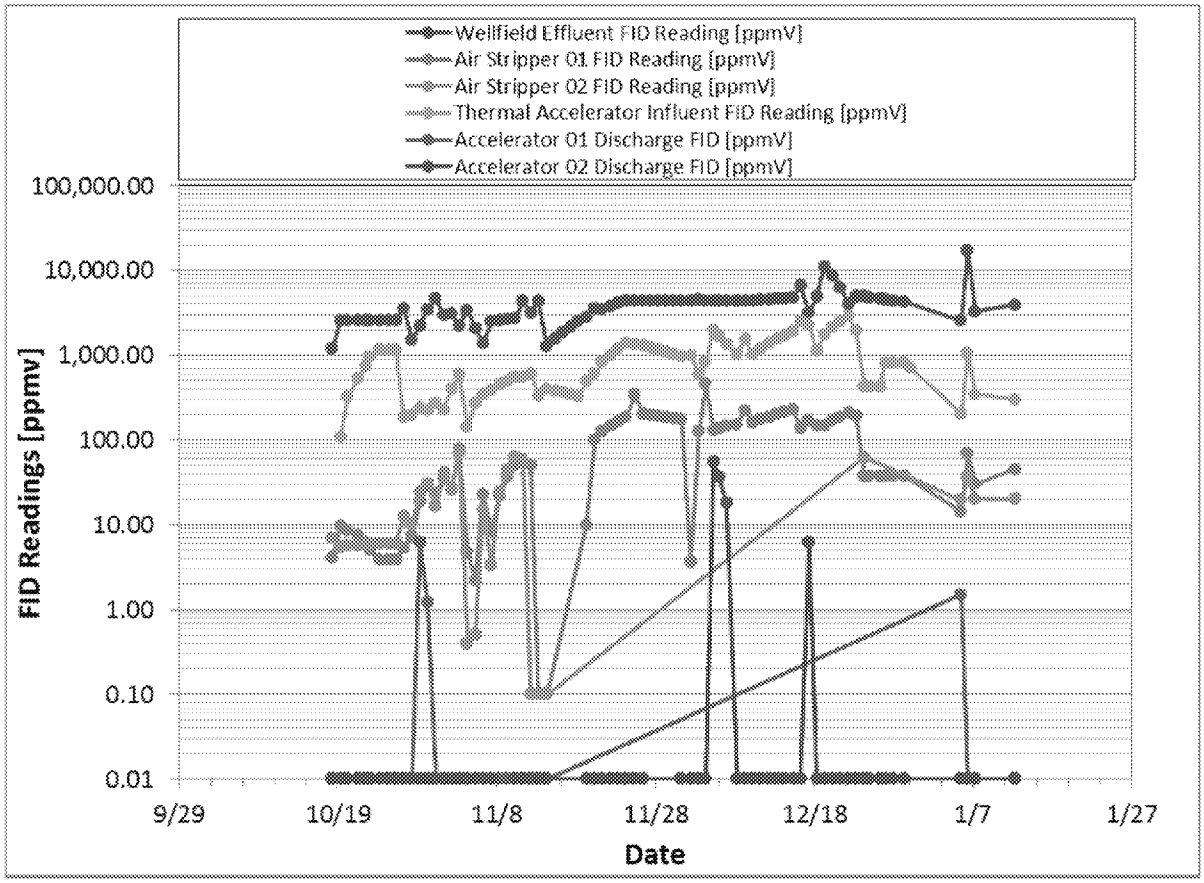


**Figure 3. FID Readings**

# 4. Mass Removal

The mass removal is calculated based on the PID, FID and laboratory data collected at the thermal accelerator influent and the LNAPL recovered. Figure 4 depicts the mass removed based on PID, FID and laboratory data. The last laboratory data received was collected on December 10, 2014. The November 12, 2014 laboratory sample is the first sample used to calculate a correction factor for the FID mass removal calculation as FID readings were not collected when the previous laboratory sample was collected on October 10, 2014.

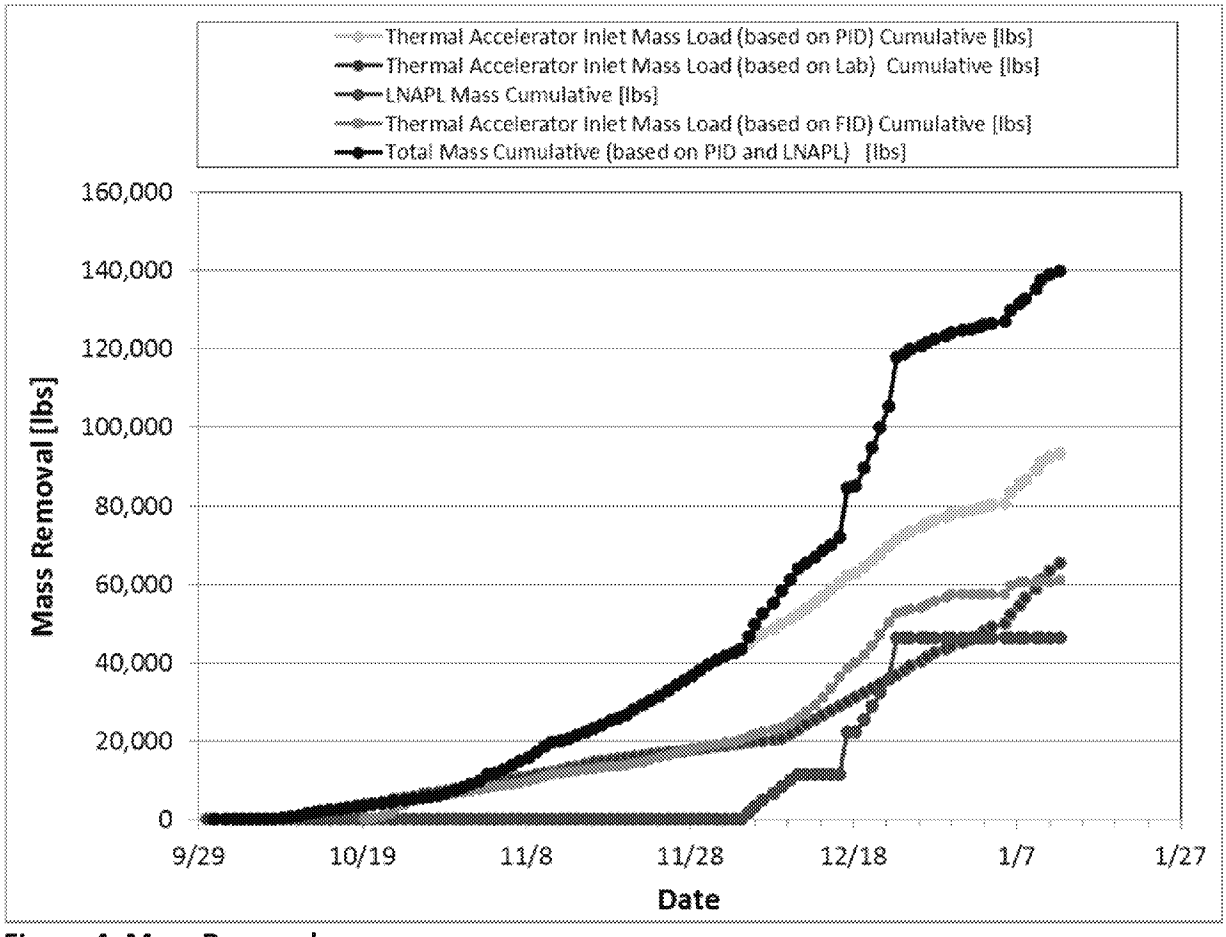


**Figure 4. Mass Removal**

*Note: A NAPL density of 6.58 lbs/gallons was used to convert the NAPL mass to pounds.*

# 5. Daily Mass Removed

Figure 5 outlines the daily mass removed as vapor and LNAPL. The total daily mass removed is the combination of vapor and LNAPL. The liquid mass removal is captured in the vapor phase due to the volatilization of liquid contaminants in the air strippers.

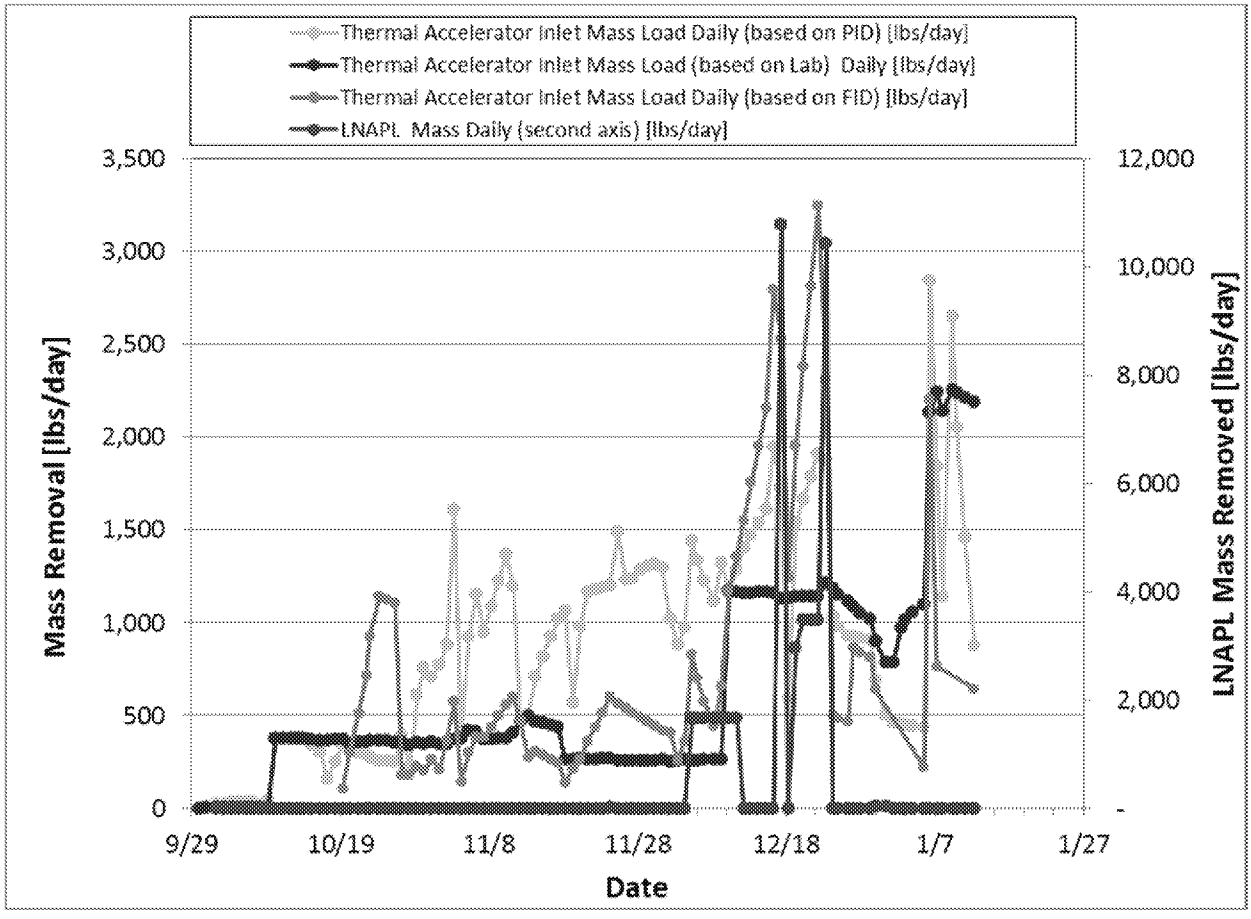


**Figure 5. Daily Mass Removed**

*Note: Laboratory data are not collected daily. The "Thermal Accelerator Inlet Mass Load (based on lab)" is an average daily rate of actual lab data collected. Note that accumulated LNAPL is pumped through the NAPL conditioning system in a batch style process.*

# 6. Power Usage

The cumulative power usage is shown below. All electricity used at the site is utilized to run the process system and steam generators.

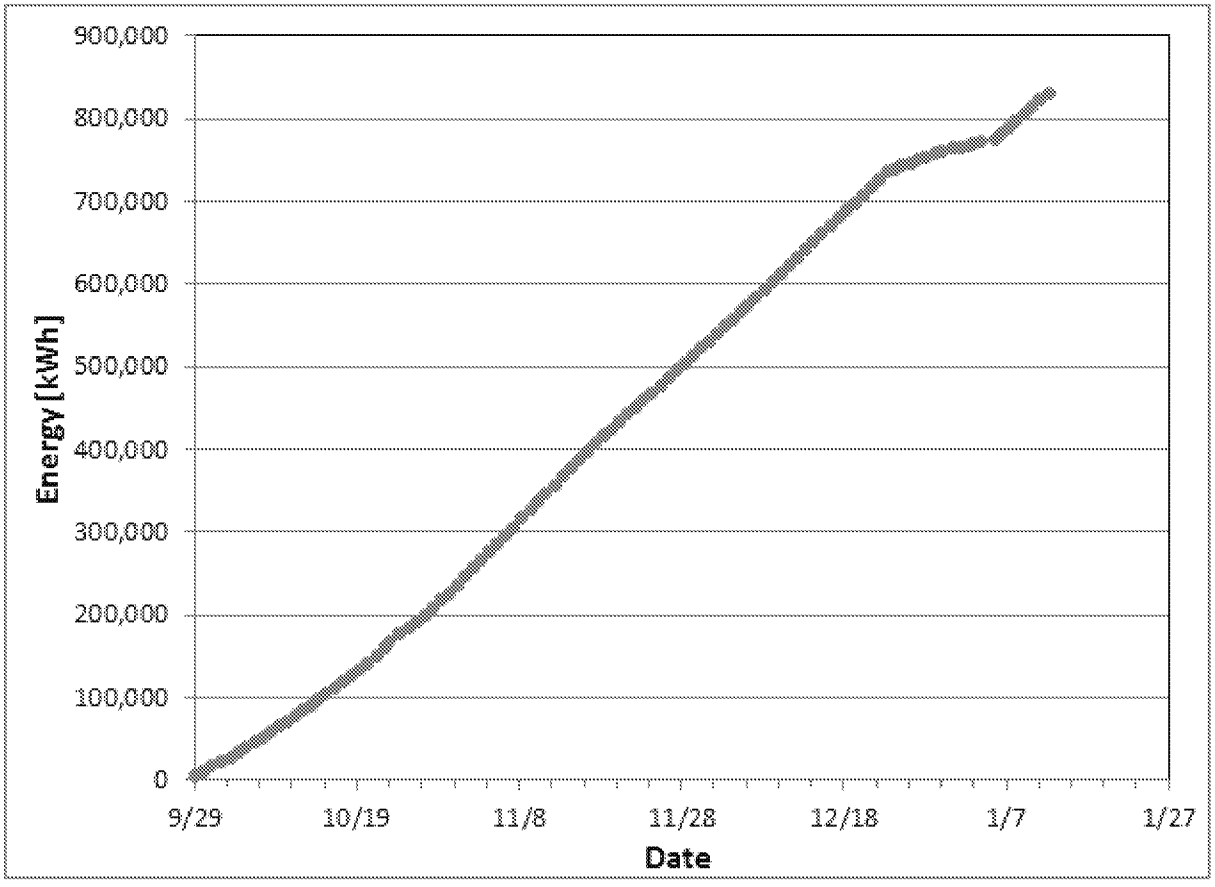


**Figure 6. Cumulative Power Usage**

# 7. Average Temperature

The average soil temperatures as degrees Celsius (°C) and degrees Fahrenheit (°F) are shown in the figure below for the entire treatment area and by treatment zone (i.e., LSZ, UWBZ and Cobble Zone [CZ]).

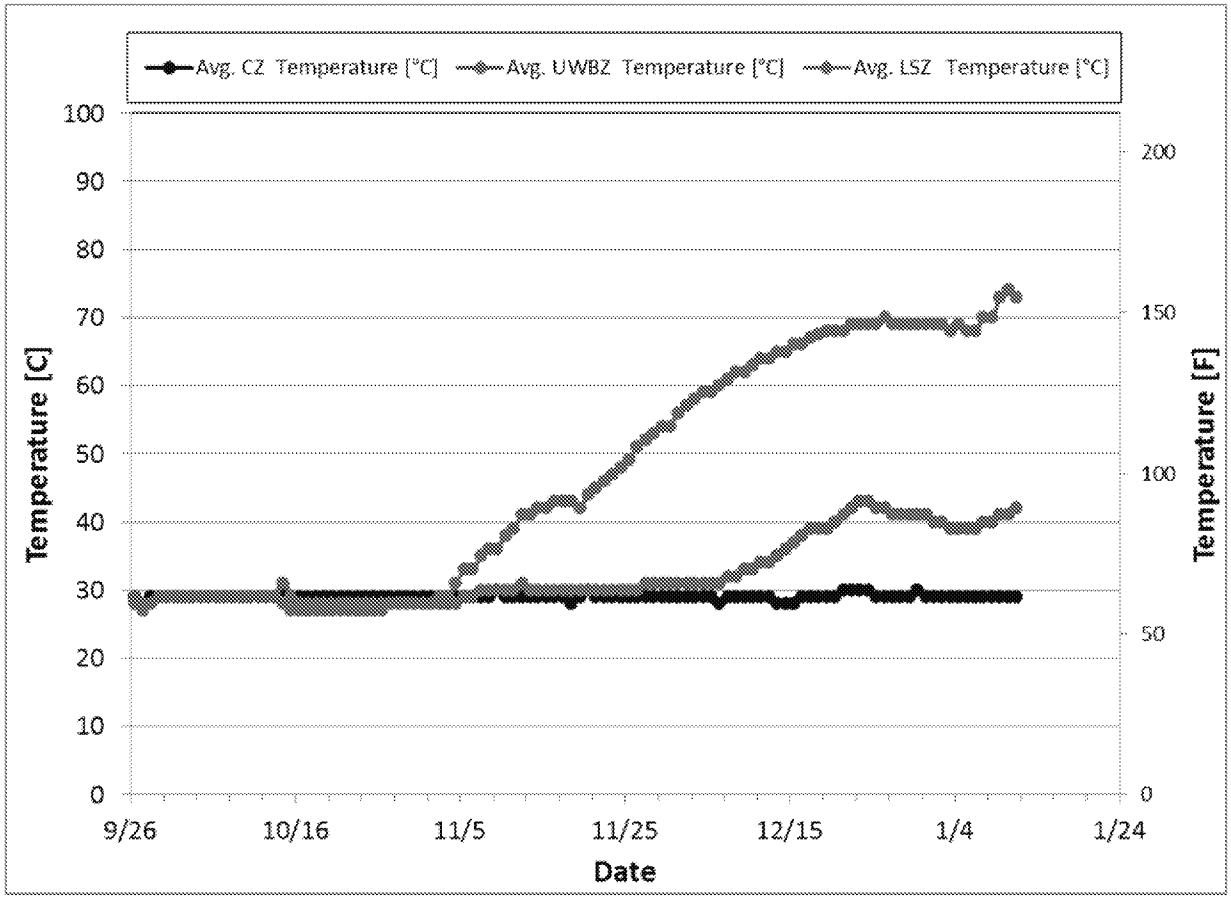


**Figure 7. Average Soil Temperatures**

# 8. Vertical and Horizontal Temperature Profiles

The following Figures 8-9 show the temperature in °C versus depth profiles for each of the 17 individual centroid (i.e., the midpoints between steam injection wells) temperature monitoring points (TMP). Figures 10-13 show the horizontal temperature distribution across the site in four depth intervals. Please note that the steam/condensate front has reached a total of 11 temperature monitoring wells (TMP3, TMP4, TMP6, TMP8, TMP9, TMP11, TMP13, TMP14, TMP15, TMP16 and TMP17). TMP3, TMP4, TMP6, TMP8, TMP9, TMP13, TMP14, TMP15, TMP16 and TMP17 show signs of temperature increase above the LSZ (located from 210 to 245 ft bgs).

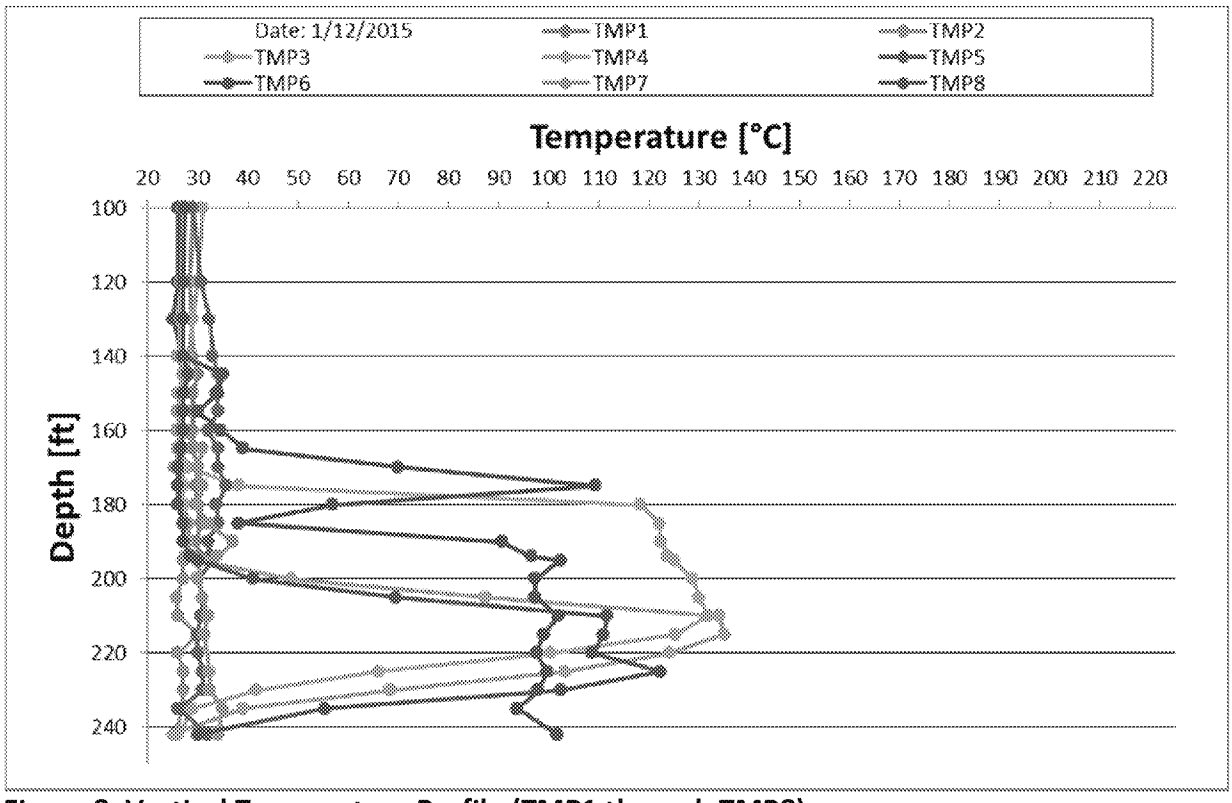


**Figure 8. Vertical Temperature Profile (TMP1 through TMP8)**

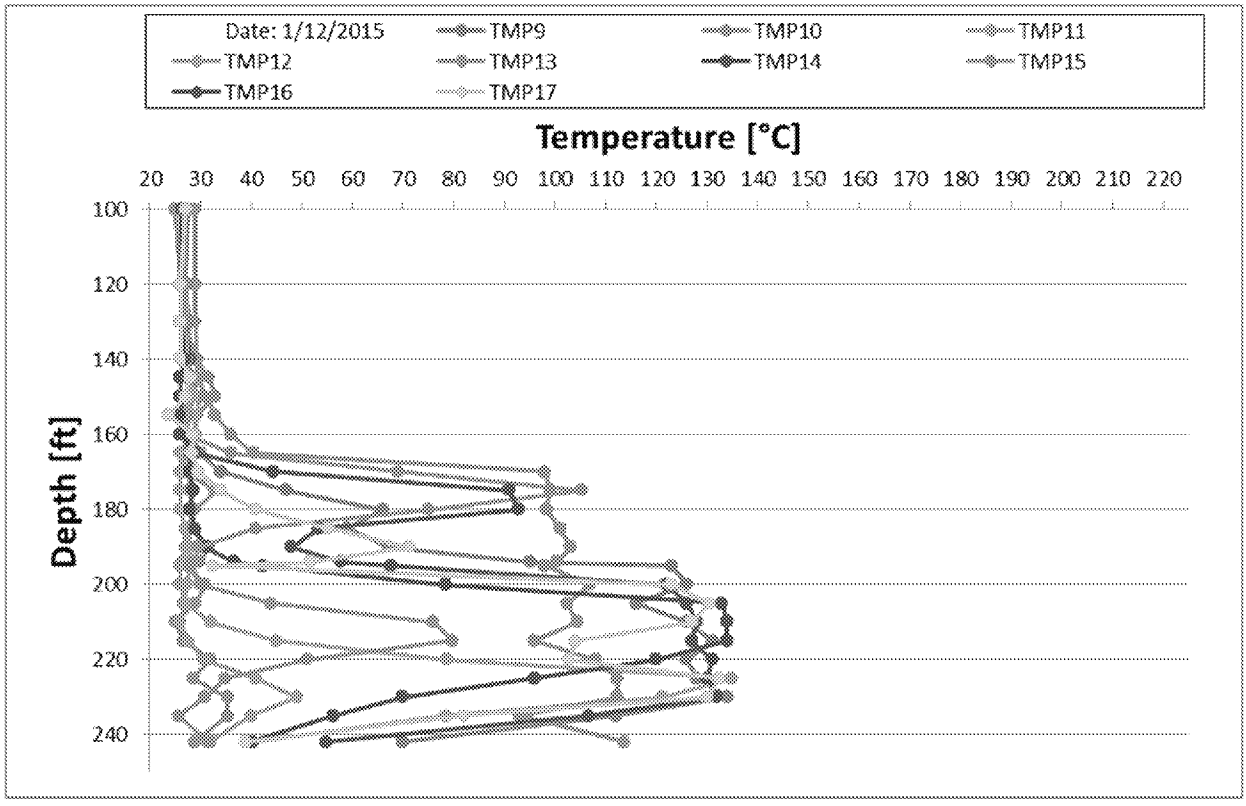


**Figure 9. Vertical Temperature Profile (TMP9 through TMP17)**

*Note: TerraTherm is currently troubleshooting the temperature data collected at TMP13 and TMP17. Data for TMP13 and TMP17 in the figure above have been interpolated based on last know valid data points.*

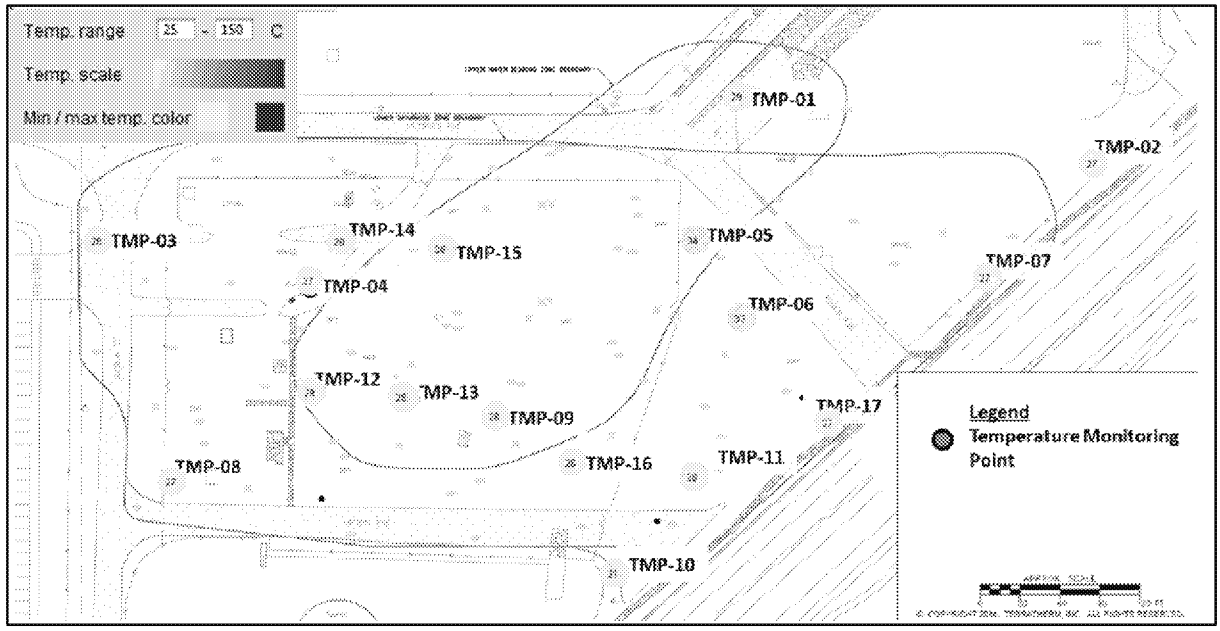


**Figure 10. Horizontal Temperature Distribution across the CZ (145-160 ft bgs) (temperatures shown in °C)**

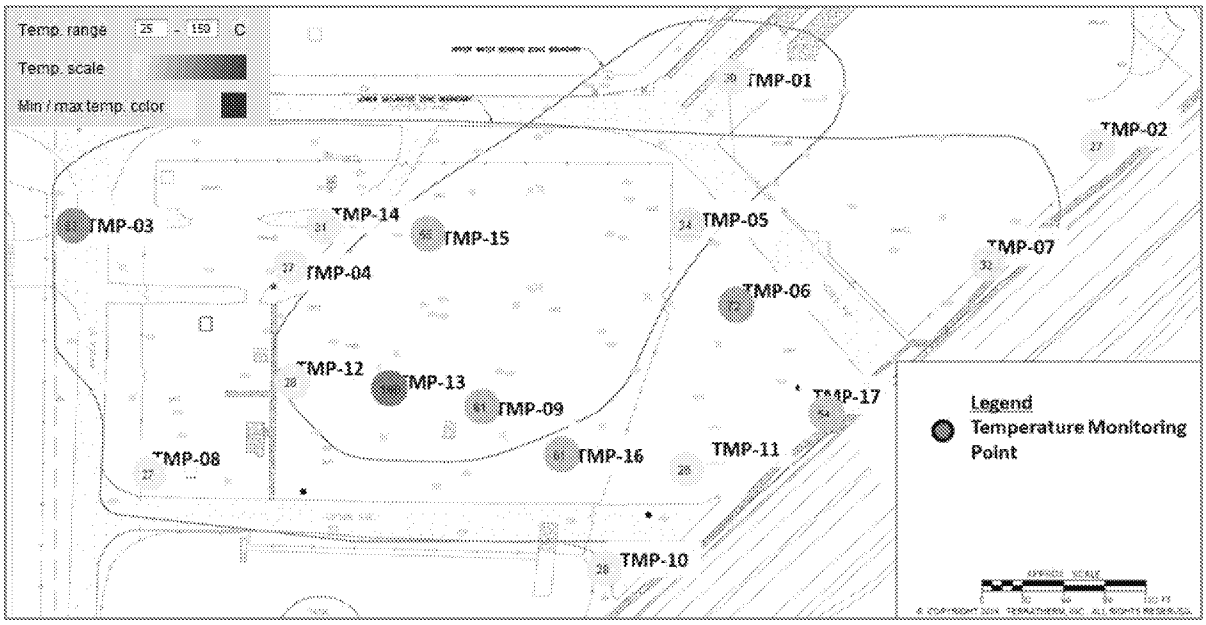


**Figure 11. Horizontal Temperature Distribution across the UWBZ (161-195 ft bgs) (temperatures shown in °C)**

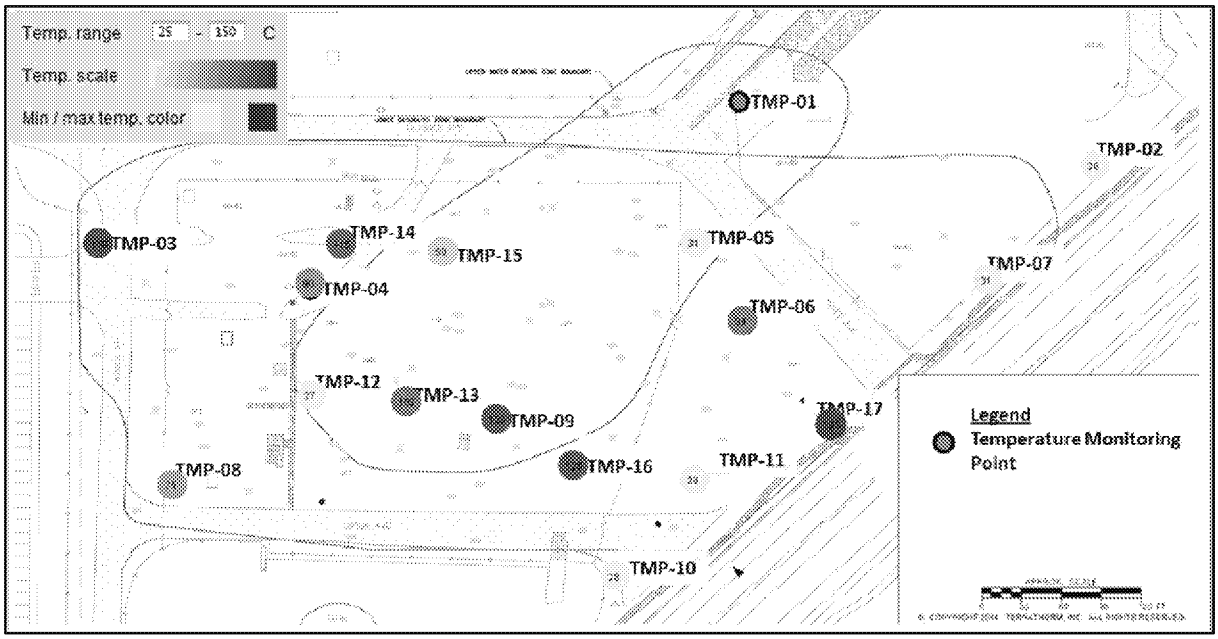


**Figure 12. Horizontal Temperature Distribution across the Lower Permeable Zone (196-210 ft bgs) (temperatures shown in °C)**

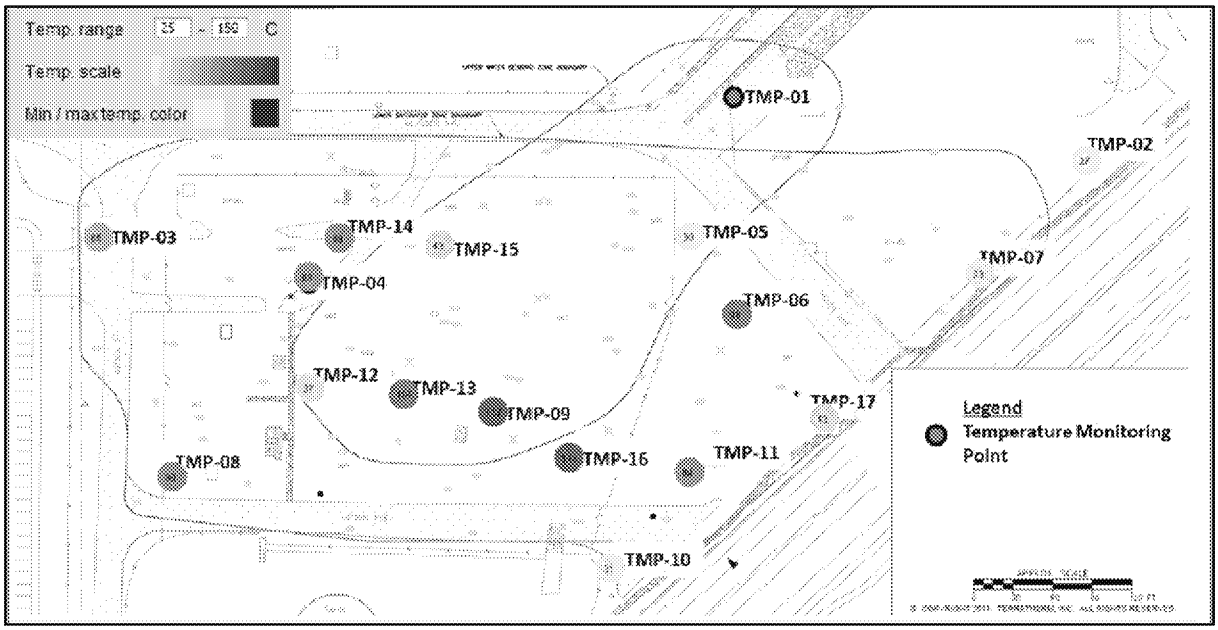


**Figure 13. Horizontal Temperature Distribution across the LSZ (211-245 ft bgs) (temperatures shown in °C)**

Figure 14 below shows the observed temperatures by depth at selected LSZ extraction wells.

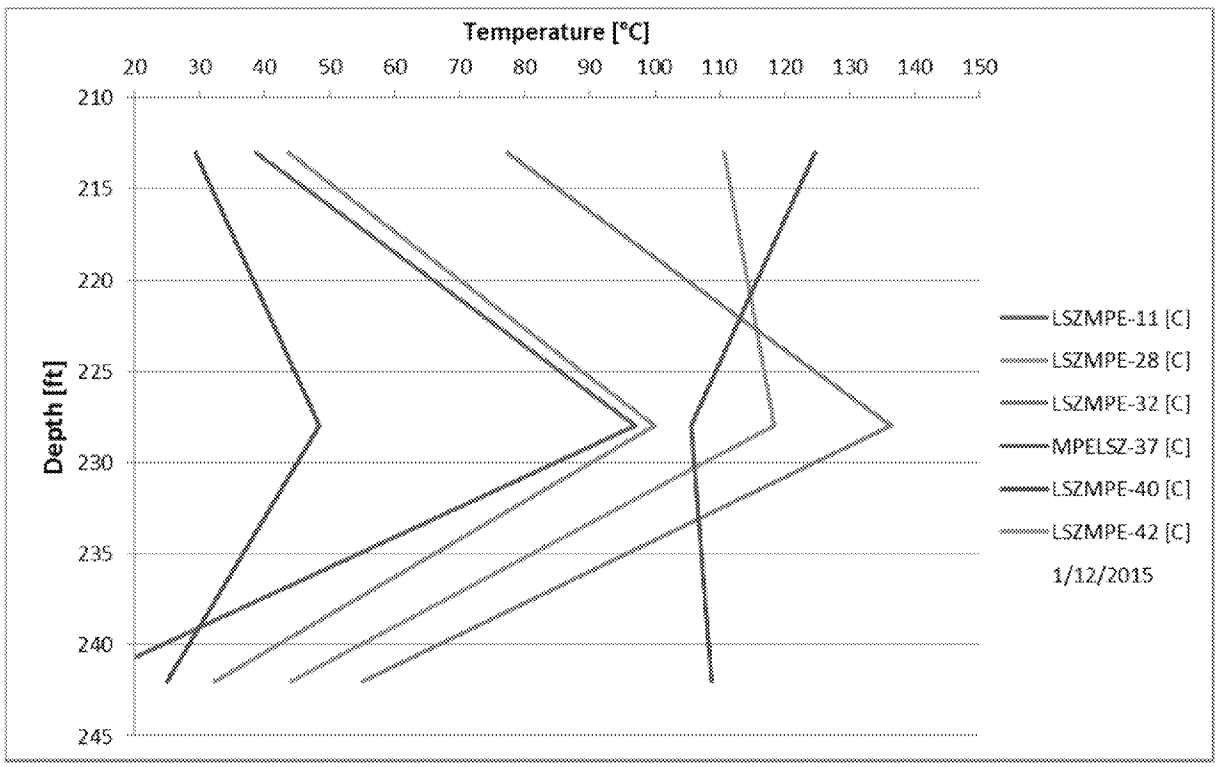


**Figure 14. Temperatures by depth at selected LSZ extraction wells (211-245 ft bgs) (temperatures shown in °C)**

# 9. Cumulative Steam Injection

The steam injection was initiated Thursday, October 16, 2014. Figure 15 below shows the cumulative steam injection for each of the three injection zones.

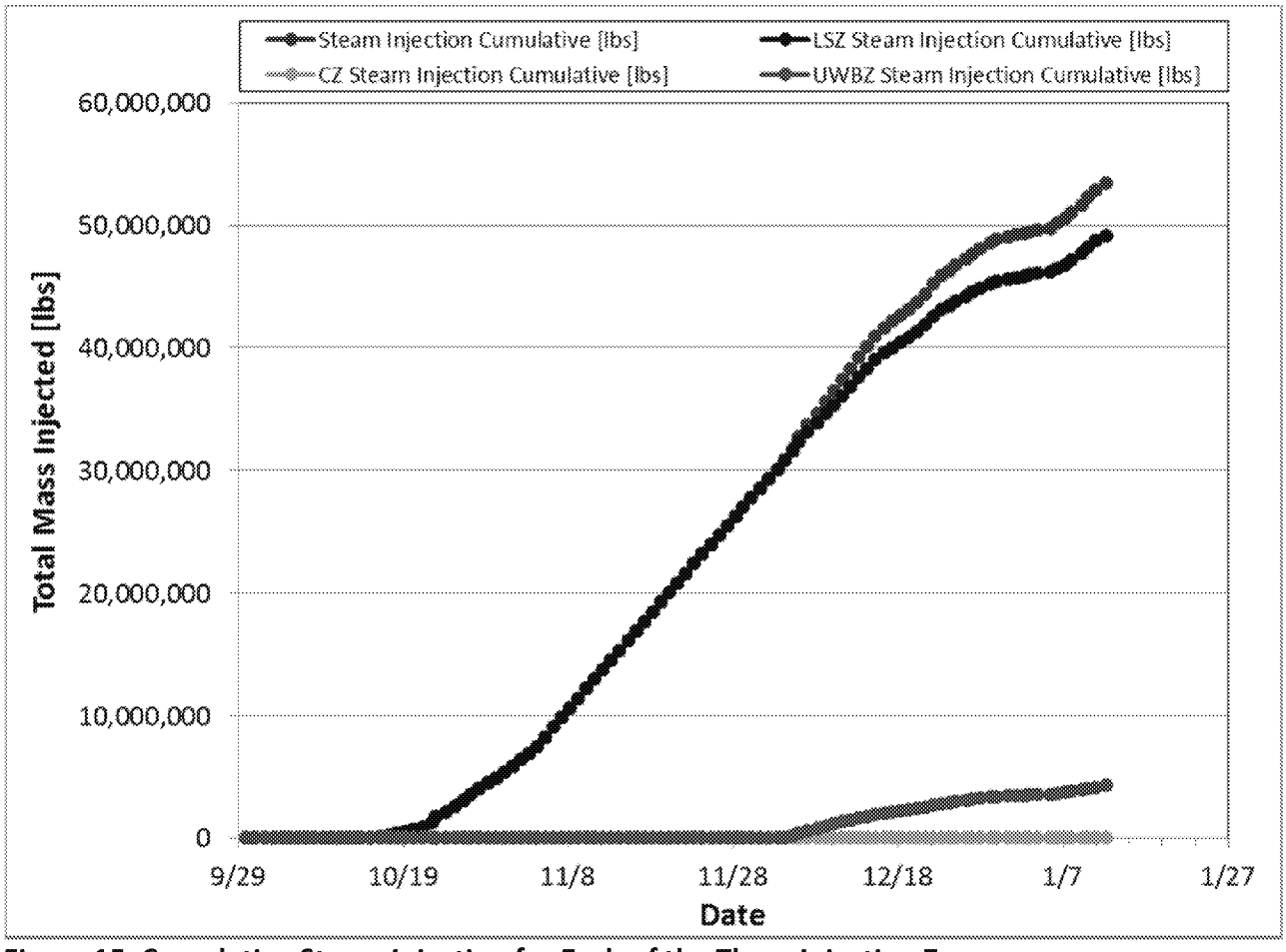


**Figure 15. Cumulative Steam Injection for Each of the Three Injection Zones**

*Note: The steam injection has not yet been initiated in the CZ.*

# 10. Steam Injection Rates

Figure 16 below shows the steam injection rates for each of the three injection zones.

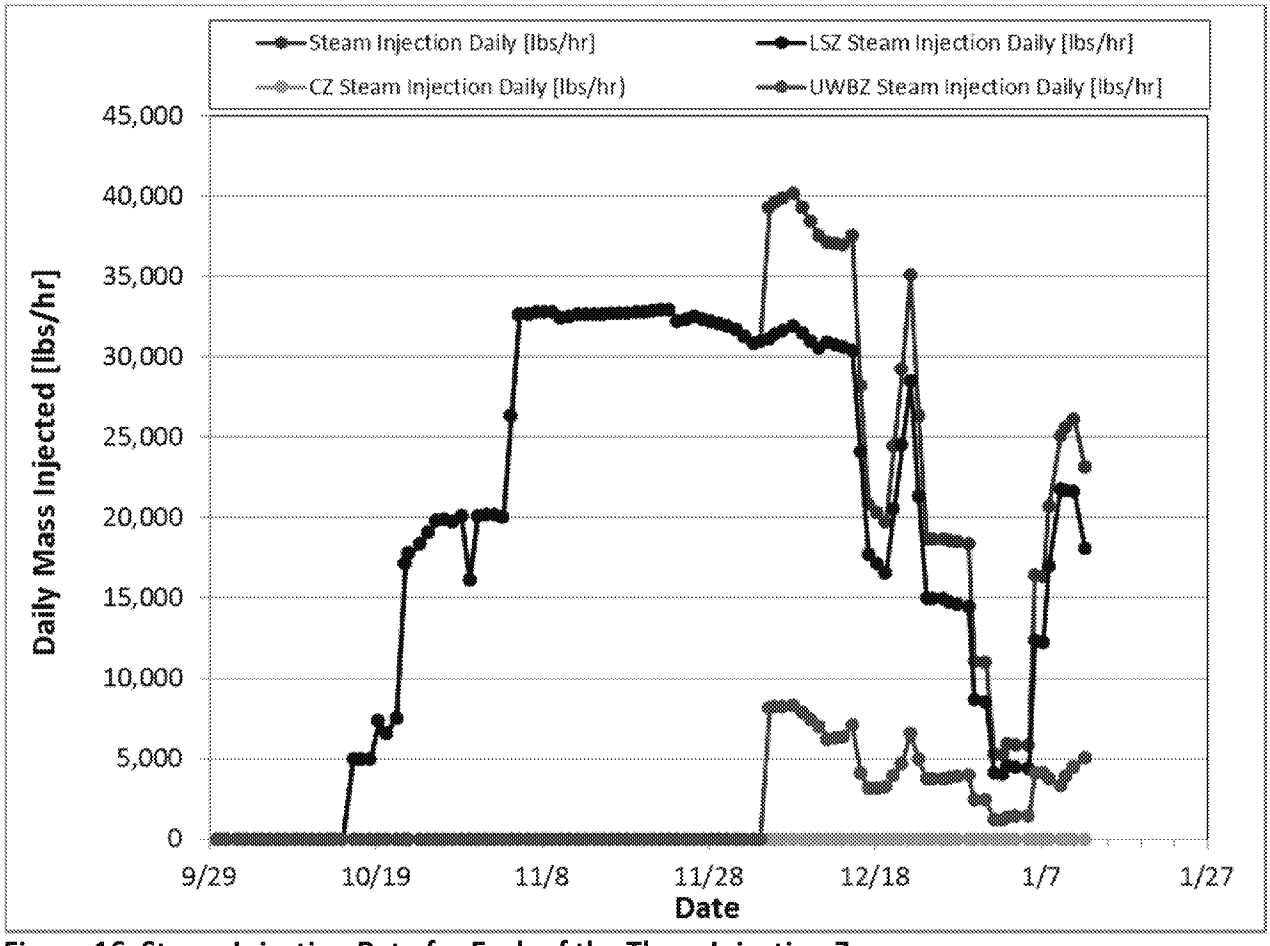


**Figure 16. Steam Injection Rate for Each of the Three Injection Zones**

*Note: The steam injection has not yet been initiated in the CZ.*

# 11. Cumulative Water Extraction by Zone

The cumulative water extraction for each of the three treatment zones is shown below in Figure 17. The cumulative water extraction is calculated based on flow meters installed at each of the 57 extraction wells (accuracy should be considered +/- 20%). Figure 17 shows the net liquid extracted from the subsurface at the site and does not include the fraction of water that is recirculated to the eductor wells and used as motive water.

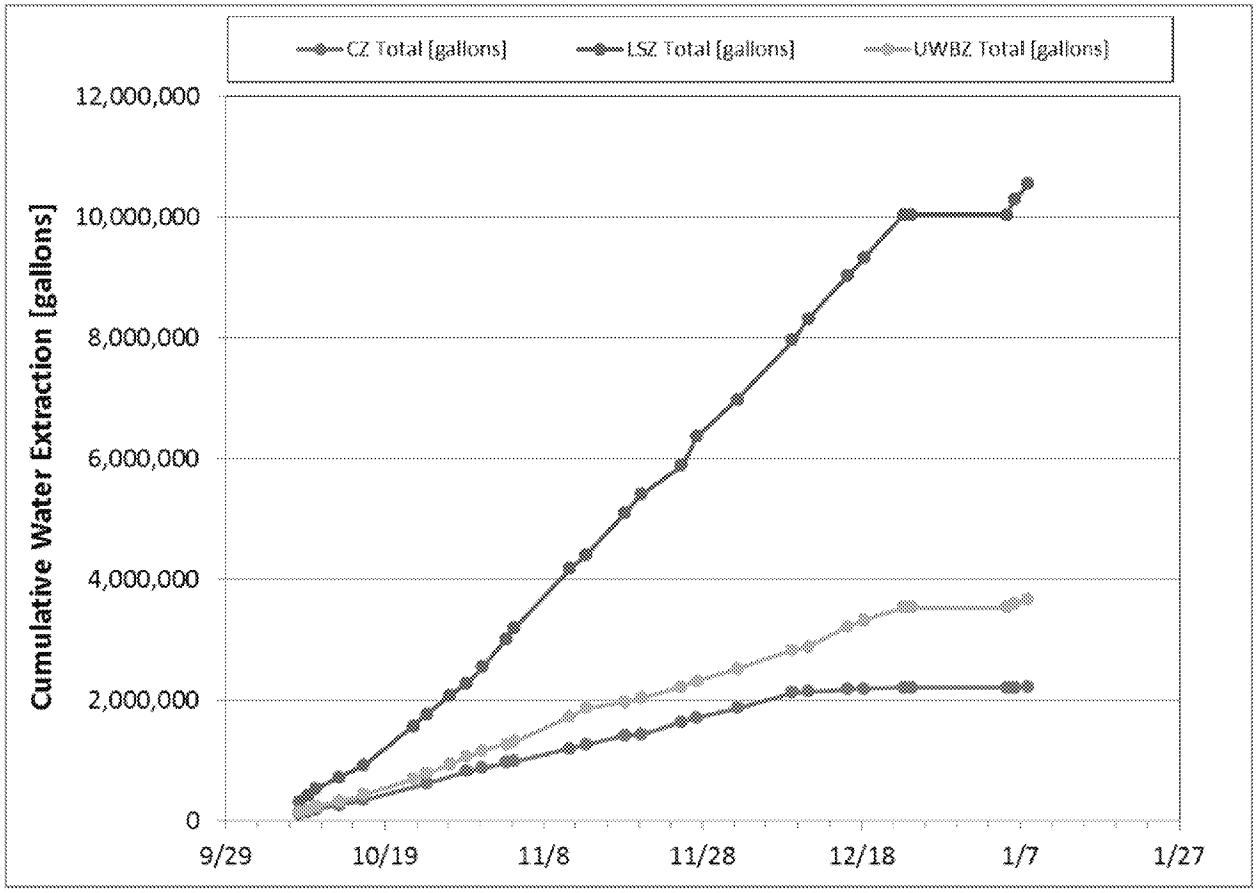


**Figure 17. Cumulative Water Extraction for Each of the Three Treatment Zones**

# 12. Water Extraction Rates by Zone

The figure below shows the water extraction rates for each of the three treatment zones. The last complete set of wellfield flow data were collected on January 8, 2015, three days after the liquid extraction system was restarted.

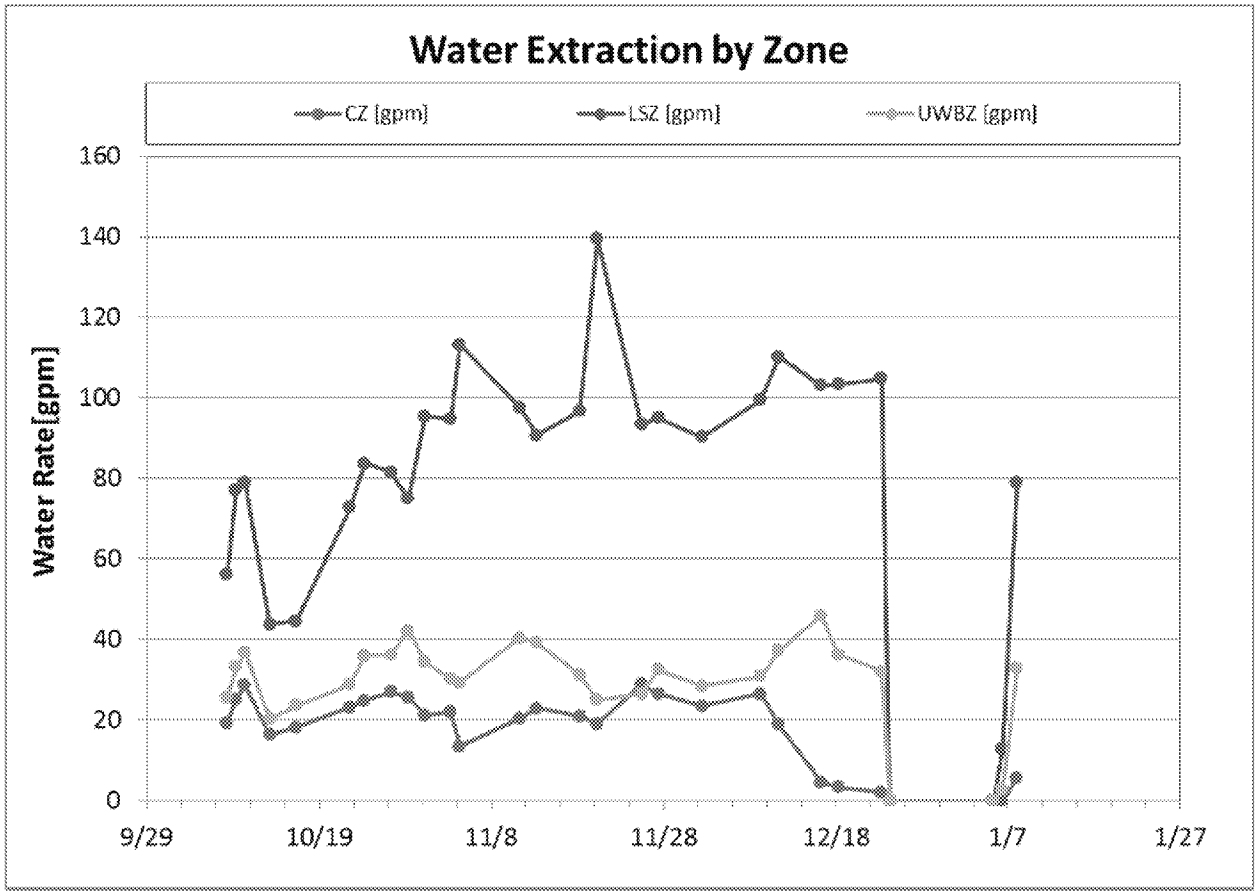


**Figure 18. Water Extraction Rates for Each of the Three Treatment Zones**

# 13. Cumulative Water Balance

The cumulative water balance for the site is shown below. The chart shows the net liquid extracted from the subsurface at the site and does not include the fraction of water that is recirculated to the eductor wells and used as motive water.

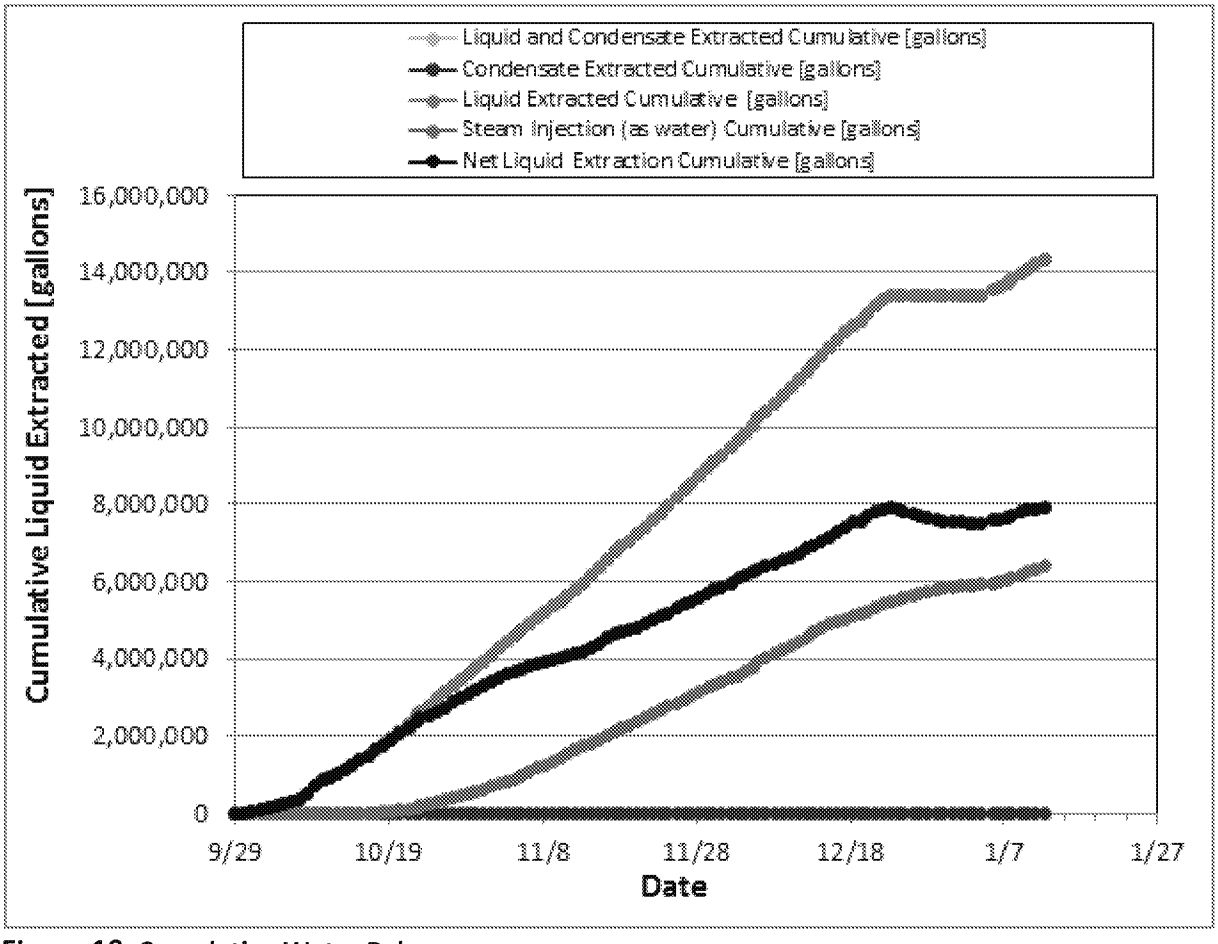


**Figure 19. Cumulative Water Balance**

*Note: At this time only limited steam or condensate has been extracted from the site.*

# 14. Water Balance Rate

The total system water extraction rates are shown in the figure below.

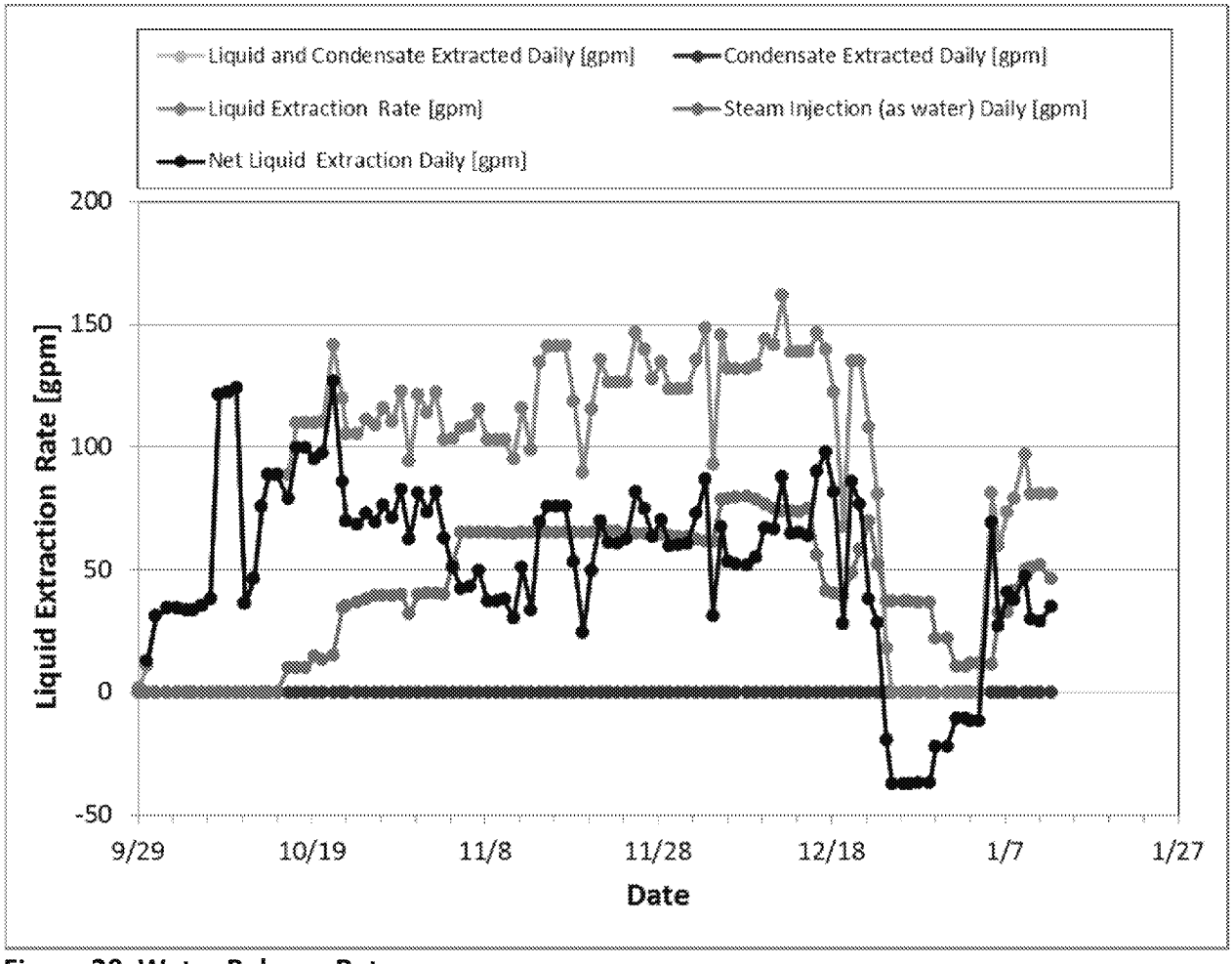


**Figure 20. Water Balance Rates**

*Note: At this time only limited steam or condensate has been extracted from the site.*

# 15. Cumulative Energy Balance

The cumulative energy balance for the site is shown below. As shown below, the temperature of the extracted wellfield water (combined motive and formation water) is increasing and energy is starting to be extracted from the subsurface.

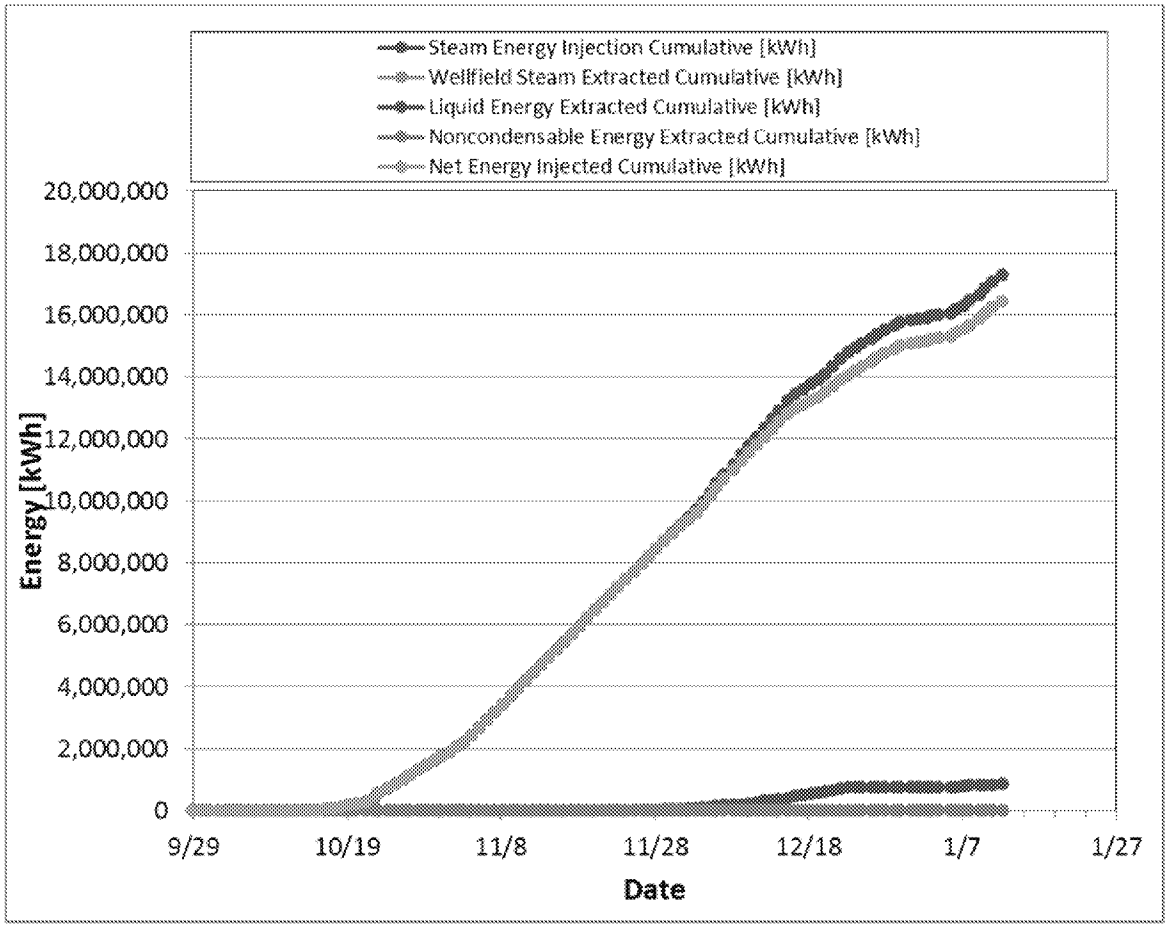


**Figure 21. Cumulative Energy Balance**

*Note: At this time only limited energy has been extracted as steam from the site.*

# 16. Energy Balance Rates

The energy balance rates are shown in Figure 22 below.

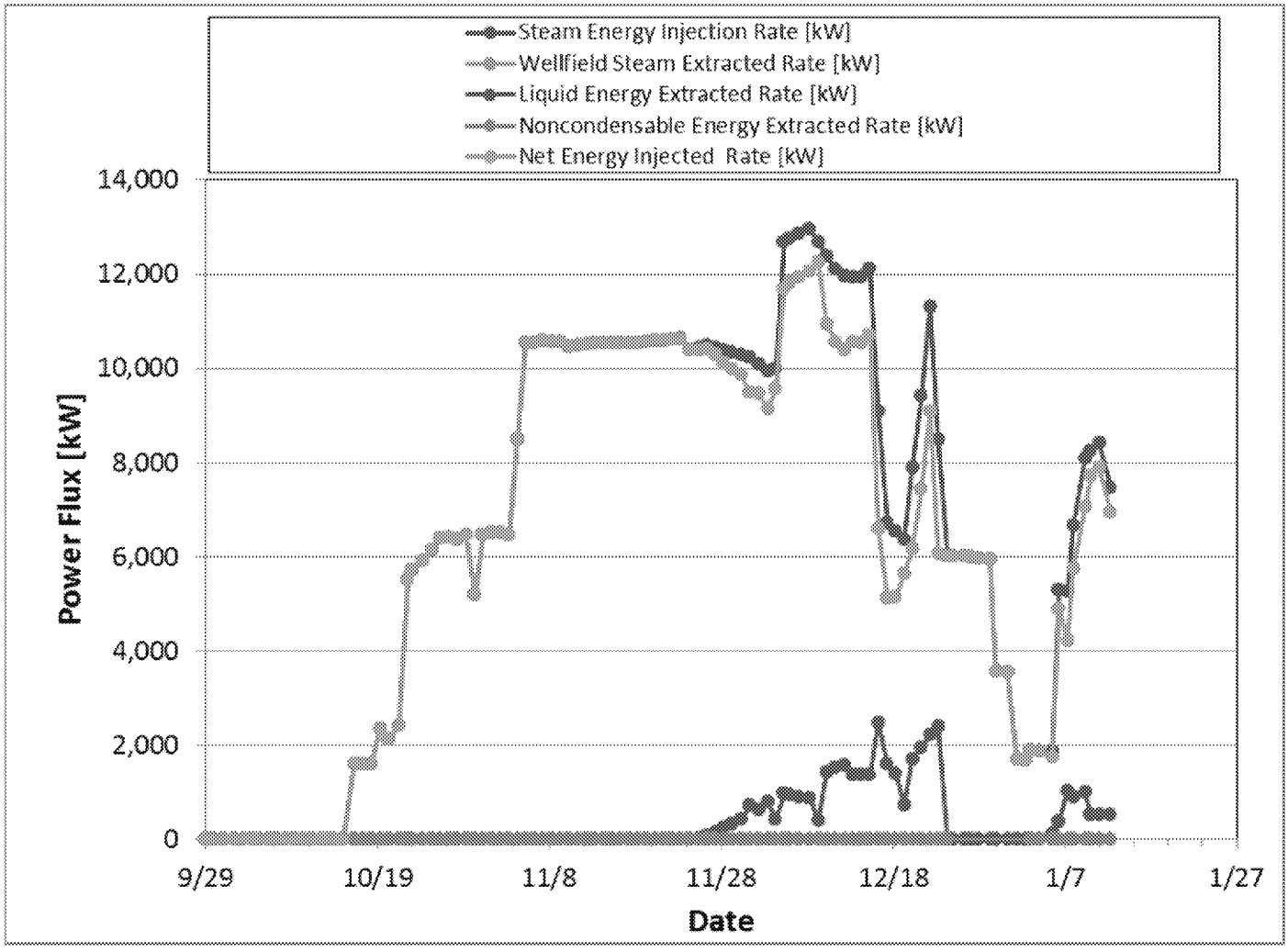


**Figure 22. Energy Balance Rates**

*Note: At this time only limited energy has been extracted as steam and liquid from the site.*

# 17. Perimeter Water Level Data

Table 2 below presents the change in perimeter groundwater elevations since SEE system startup. The readings collected on September 24, 2014 (not shown) represent baseline conditions. A negative number shows that the groundwater elevation is lower than the baseline elevation, thus indicating an inward hydraulic gradient into the treatment zone. Liquid extraction began on September 29, 2014. Perimeter water level data are collected on a weekly basis. The regional groundwater table at the Site is increasing at a rate of approximately 1.5 ft/year. Thus, each measured value shown in Table 2 has been corrected to take the regional changes into account.

On January 11, 2015 shows an increase in groundwater levels were observed especially in the LSZ. Based on this information the injection rates in the LSZ steam injection wells were decreased to approximately 1,100 lbs/hr on January 12, 2015. A new round of groundwater levels data was collected on January 13, 2015 showing a substantial decrease in groundwater levels.

**Table 2. Perimeter Groundwater Elevation Changes**

| | 12/19/2014 | | 12/23/2014 | | 12/26/2014 | | 1/2/2015 | | 1/11/2015 | | 1/13/2015 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Monitoring Well | Change from Baseline | Change from Previous | Change from Baseline | Change from Previous | Change from Baseline | Change from Previous | Change from Baseline | Change from Previous | Change from Baseline | Change from Previous | Change from Baseline | Change from Previous |
| **CZ/UWBZ Wells** | | | | | | | | | | | | |
| ST012-C01 | -0.52 | 0.15 | -0.51 | -0.03 | -0.49 | -0.03 | -0.14 | -0.38 | -0.38 | 0.20 | -0.32 | -0.07 |
| ST012-C02 | -0.91 | -0.01 | -0.80 | 0.13 | -0.71 | 0.10 | -0.52 | 0.22 | -0.44 | 0.12 | -0.41 | 0.04 |
| **UWBZ Wells** | | | | | | | | | | | | |
| ST012-RB-3A | -1.49 | -0.85 | -0.76 | 0.75 | -0.53 | 0.24 | -0.39 | 0.17 | -0.40 | 0.03 | -0.18 | 0.23 |
| ST012-U02 | -1.39 | -1.10 | -0.66 | 0.75 | -0.42 | 0.25 | -0.25 | 0.20 | -0.23 | 0.06 | 0.07 | 0.31 |
| ST012-U11 | -1.71 | -1.17 | -0.67 | 1.06 | -0.30 | 0.38 | -0.47 | -0.14 | -0.45 | 0.06 | -0.08 | 0.38 |
| ST012-U12 | -1.75 | -1.35 | -0.50 | 1.27 | -0.20 | 0.31 | -0.42 | -0.19 | -0.15 | 0.31 | 0.24 | 0.40 |
| ST012-U37 | -1.63 | -0.93 | -0.69 | 0.96 | -0.52 | 0.18 | -0.32 | 0.23 | -0.39 | -0.03 | -0.16 | 0.24 |
| ST012-U38 | -1.13 | -0.65 | -0.72 | 0.43 | -0.53 | 0.20 | -0.39 | 0.17 | -0.32 | 0.11 | -0.11 | 0.22 |
| **LSZ Wells** | | | | | | | | | | | | |
| ST012-W11 | -4.95 | -3.29 | -0.31 | 4.66 | -4.39 | -4.07 | -2.11 | 2.31 | 1.56 | 3.71 | -0.79 | -2.34 |
| ST012-W12 | -4.58 | -3.22 | -0.56 | 4.04 | 0.55 | 1.12 | -1.64 | -2.16 | 1.66 | 3.34 | 0.09 | -1.56 |
| ST012-W24 | -2.86 | -1.85 | -0.59 | 2.29 | -1.72 | -1.12 | -1.36 | 0.39 | 1.74 | 3.14 | -0.59 | -2.32 |
| ST012-W30 | -3.40 | -3.52 | 0.69 | 4.11 | -0.69 | -1.37 | -3.51 | -2.79 | 2.30 | 5.85 | 1.32 | -0.98 |
| ST012-W34 | -3.26 | -2.65 | -0.46 | 2.82 | -1.30 | -0.83 | -1.12 | 0.21 | 1.57 | 2.73 | 0.00 | -1.56 |
| ST012-W36 | -3.17 | -3.56 | 0.26 | 3.45 | -0.71 | -0.96 | -0.97 | -0.23 | 2.13 | 3.14 | 0.53 | -1.59 |
| ST012-W37 | -3.63 | -2.66 | -0.24 | 3.40 | -0.50 | -0.25 | -1.93 | -1.39 | -1.65 | 0.32 | 1.36 | -3.28 |
| ST012-W38 | -2.91 | -2.37 | -0.48 | 2.45 | -1.15 | -0.66 | -0.94 | 0.24 | 1.40 | 2.38 | 0.17 | -1.22 |

Figure 23 shows the groundwater elevation trends since system startup. The regional groundwater table correction has not been added to Figure 23.

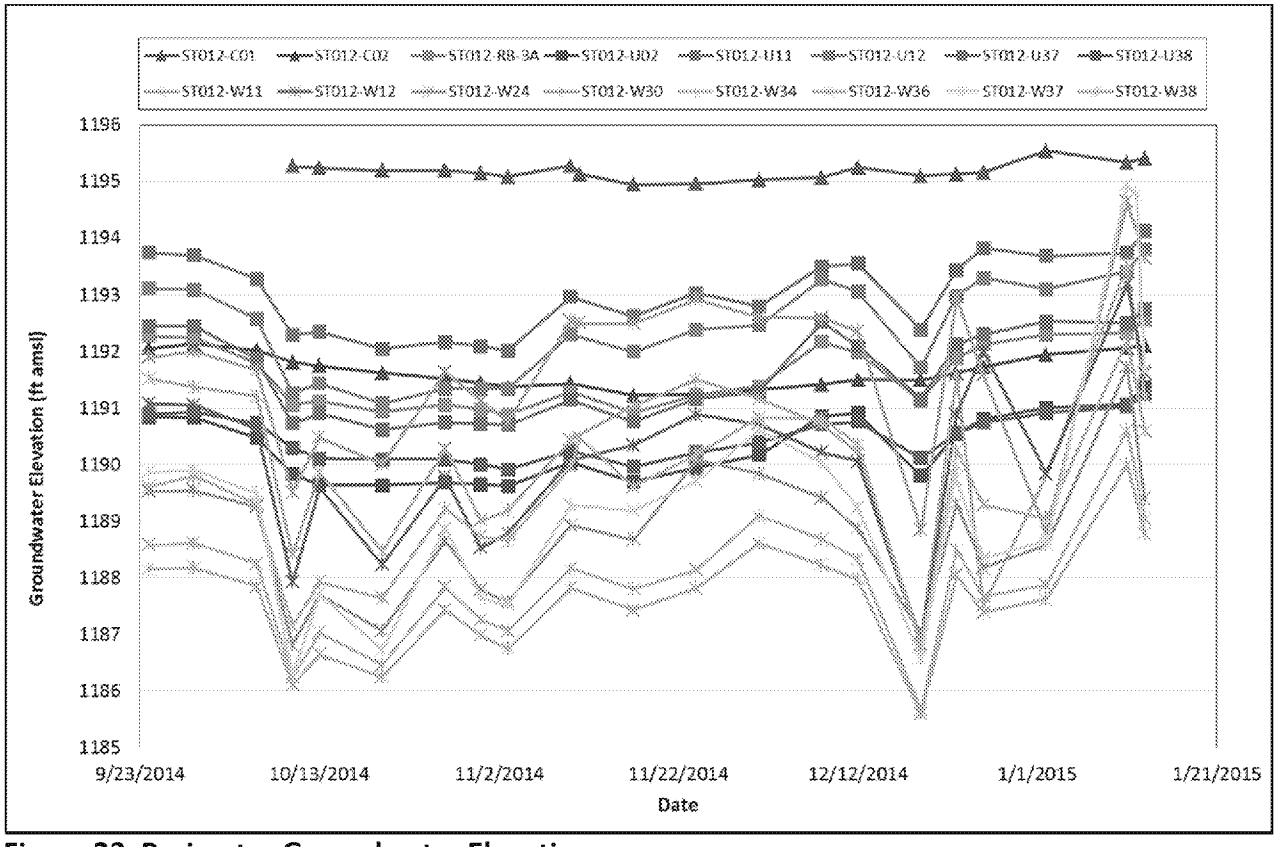


**Figure 23. Perimeter Groundwater Elevations**

Table 3 below presents the measured LNAPL thicknesses of the perimeter wells at the site. The readings collected on September 24, 2014 represent baseline conditions while the readings collected after are during SEE operations. Perimeter LNAPL thickness data is collected on a weekly basis.

**Table 3. Perimeter LNAPL Thicknesses (ft)**

| Monitoring Well | 12/26/2014 | 1/2/2015 | 1/2/2015 | 1/11/2015 | 1/12/2015 | 1/13/2015 |
|---|---|---|---|---|---|---|
| **CZ/UWBZ Wells** | | Before Bailing | After Bailing | Before Bailing | After Bailing | |
| ST012-C01 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| ST012-C02 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| **UWBZ Wells** | | | | | | |
| ST012-U02 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| ST012-U11 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| ST012-U12 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| ST012-U37 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| ST012-U38 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| ST012-RB-3A | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| **LSZ Wells** | | | | | | |
| ST012-W11 | 0.00 | 0.52 | 0.52 | 0.46 | 0.46 | 0.48 |
| ST012-W12 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| ST012-W24 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| ST012-W30 | 0.01 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| ST012-W34 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| ST012-W36 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| ST012-W37 | 0.74 | 5.88 | 0.30 | 10.15 | 0.12 | 0.11 |
| ST012-W38 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

On December 1, 2014, temperatures at selected perimeter wells were added to the monitoring program. The figure below shows the temperatures recorded at the wells included in the monitoring program.

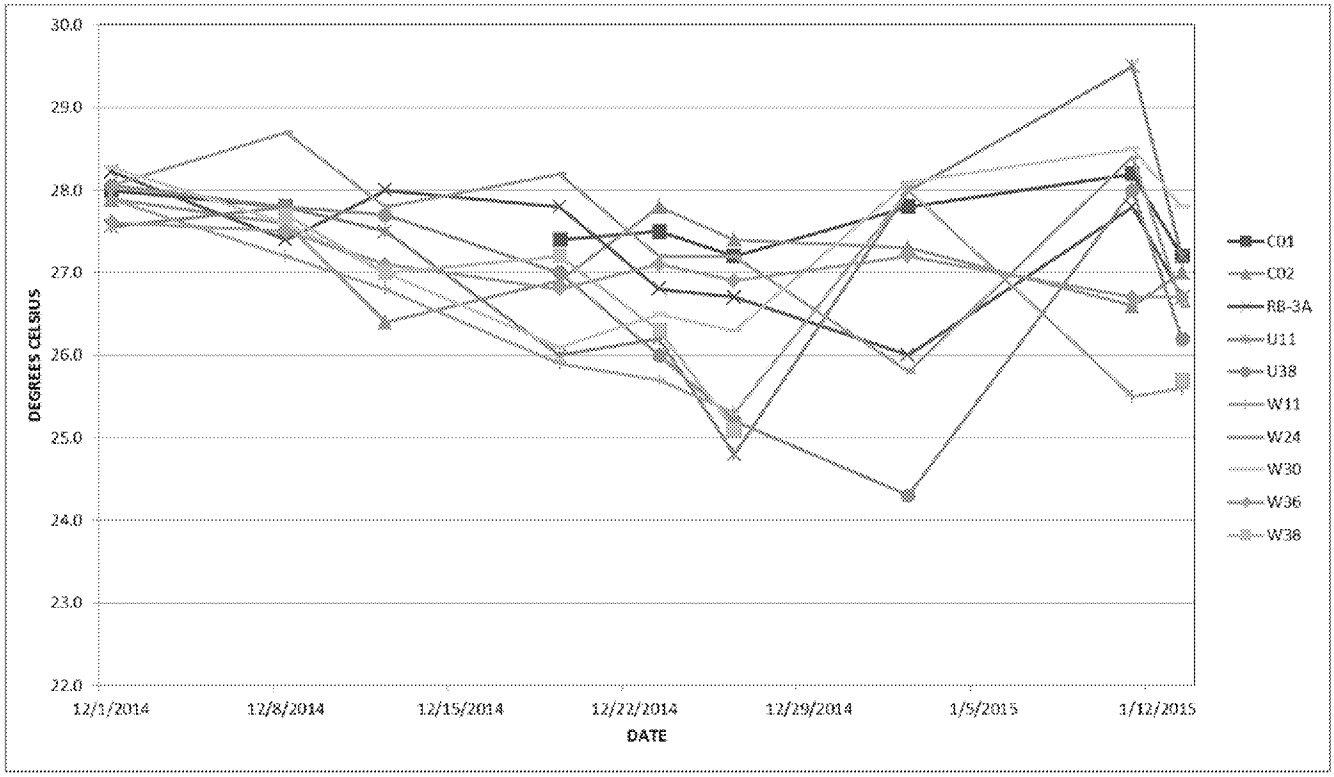


**Figure 24. Perimeter Groundwater Temperatures**

# 18. Natural Gas Usage

The following figure shows the natural gas usage rate in cubic feet per hour (cf/hr) and cumulative natural gas use in cubic feet (cf) to date at the site.

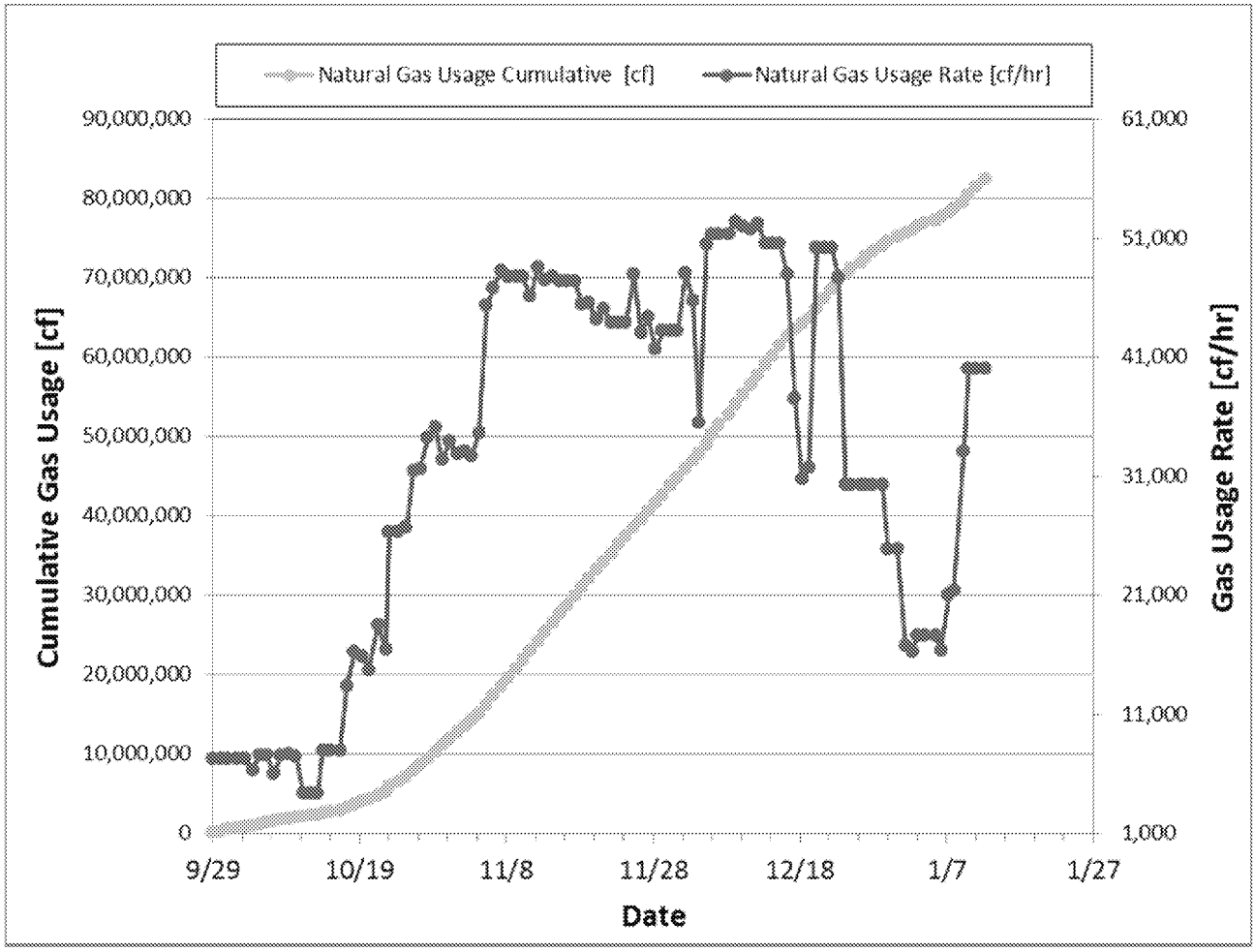


**Figure 25. Natural Gas Usage**